INNOVATIVE “MICROSATE” CAGE CULTURE SYSTEMS FOR LIVELIHOOD AND NUTRITIONAL SECURITY: A PARTICIPATORY APPROACH

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Abstract —

Aquaculture is the fastest-growing food production sector in the world and is considered to be of vital importance for the livelihood and nutritional security. Here we describe an innovative "Microsate" cage fish culture model for alternative income generation and livelihood security of inland fisherfolks. The "Microsate" were implemented in the Vembanad lake close to Azhikode bar mouth along the West coast of India. The programme implementation have processes such as stakeholder selection, site selection, fabrication of cages, monitoring the culture process, harvesting and marketing of the fish. The selected male and female stakeholders members were trained for "Microsate" fabrication and rearing of the fish. Hatchery reared Asian seabass (Lates calcarifer) and indigenous Pearl spot (Etroplus suratensis) fingerlings were stocked in the cages. They were fed with pellet feed as well as trash fish at dawn and dusk period. After the seven months of "Microsate" culture, plate size fishes were harvested and sold out in the domestic market with premium price. The income generated equally divided among the members which was used for the second culture. The newly developed, ecofriendly microsate cage culture model can be used as a replicable model to address the livelihood insecurity of the rural fisher folk. Most importantly it acts as a means for ensured alternative livelihood and to culture the indigenous fish stocks which are presently overexploited and are under the threat of extinction. This type of food production systems can decrease the fishing pressure on indigenous fish species and also generate alternative income for the inland rural fishers. "Microsate" cage fish culture endeavor for livelihood and nutritional security of the rural fisherfolks has become a promising intervention in India.

Key words: Microsate cage culture, *Asian Seabass*, Livelihood security, Fisherfolks, South west coast of India.

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1. INTRODUCTION

Over the past 50 years, world's fishing industry has largely changed from a localized and coastal trade to a global activity, leading to a worldwide depletion in fish catch, affecting the livelihood and nutritional security of the traditional rural fisher folks (Vijayan et al., 2007). Most stocks of the top ten species, which account for about 30 percent of the world marine capture fisheries production are satiated/overexploited and, therefore, cannot be expected to produce any increase in the near future (Grainger *et al.,* FAO 2008). Presently, the capture fisheries industry has reached a plateau and no further growth can be expected from this sector. Over-exploitation in the near-shore waters, limited access to capture fisheries and the need for diversification, makes mariculture one of the most appropriate alternatives (Agriculture Research and Education for the Eleventh Five Year Plan 2007-2012). Therefore the development of culture based fisheries (Aquaculture) seems to be the most viable alternative to revive the positive growth of fisheries sector and related industry

Aquaculture, which is the fastest-growing food production sector in the world, contributes about 30 percent of the total fish production, and this share is increasing each year. Aquaculture sector is considered to be of vital importance for the livelihood and nutritional security of the rural and coastal populations, as well as for contributing to the export earnings of the country. India is bestowed with a coastline of 8,129 km, with a continental shelf area of about 0.5 million sq km. There are about 3015 million hectare (ha) reservoirs, 2025 million ha of lakes and ponds, 0.82 million ha of beels, oxbow lakes, derelict water bodies and 1.19 million ha of brackish water areas (Agriculture Research and Education for the Eleventh Five Year Plan 2007-2012). These resources are still underutilized or neglected in terms of production, and can be converted in to successful farming ventures. In this context, cage aquaculture is coming up as a promising venture and offers the farmer a chance for optimally utilizing the existing water resources which in most cases have only limited uses for other purposes. By integrating the cage culture system into the aquatic ecosystem, the carrying capacity per unit area is maximized because the free flow of current brings in fresh supply of water, ensuring the optimum growth by removing the metabolic wastes, excess feed and faecal matter. Thus economically speaking, cage culture is a low impact farming practice with high economic returns. In view of the high production attainable in cage culture systems and the presence of large sheltered coastal waters in many countries, marine cage farming can play a significant role in increasing the fish production (Beveridge, 1983). Rational utilization of these potential resources by adopting fish farming methodologies like cage culture can significantly improve the aquaculture production status of India. Modern cage culture began in the 1950s with the advent of synthetic materials for cage construction and by the 1980s many fish species were cage cultured. Today, cage culture is receiving more attention from both researchers and commercial producers and fishes are cultured in cages of various designs and sizes. Asian Sea bass (*Lates calcarifer*) turned out to be a suitable candidate species for cage culture in South east Asia and has been widely cultured in China, Hong Kong, Indonesia, Malaysia, Philippines, Singapore, Thailand, Vietnam and Australia.

The present innovative venture was formulated to develop a new "Microsate" cage fish culture model for alternative income generation and livelihood security with an eye on the conservation of native, threatened fishery stocks along the Indian coast. The objectives of the present study are:

- To develop "Microsate", location specific, eco-friendly cage fish culture units.
- To improve upon the existing human resources potential through participatory "Microsate" initiatives.
- To critically analyze the sustainability of the cage culture system with participatory ownership

Furthermore the small scale "Microsate" cage fish culture initiative will act as an alternative income generating model, ensuring the nutritional security of the people. In this background an initiative has been taken up to develop an artisanal, "Microsate" cage culture model suitable for the culture of indigenous candidate fish species.

2. MATERIALS AND METHODS

The cage culture study was conducted in the Vembanad lake close to Azhikode bar mouth along the West coast of India (Fig.1). "Microsate" floating cage culture units were developed and implemented through selected fisherfolk groups. These innovative cage units are suitable for culturing fin fishes in running water systems. Popular cultivable fin fish, Asian seabass (*Lates calcarifer*) and indigenous pearl spot (*Etroplus suratensis*) were selected as candidate species. The major processes involved in the implementation of the "Microsate" culture were stakeholder selection, site selection, fabrication of cages, monitoring the culture process, harvesting and marketing. The participation of the stakeholders of the "Microsate" units was throughout the seven months of culture process. The details of the process are given below.

2.1 Selection of stakeholders

A detailed household survey was conducted among the rural fisherfolks in the study area prior to initiating the work. Based on the survey, community stakeholders of men and women groups were identified and selected for the implementation of the programme. The main criteria considered for selecting the stakeholders were their financial disposition and interest towards participation in the project.

2.2 Site selection and Fabrication of "Microsate" floating cages

A detailed bathymetric survey was conducted in the confluence of Periyar river to Arabian Sea along the West coast of India (10^0 11' 26.21" N and 76^0 11' 14.47" E) for selecting the sites for installing the sages. The cage sites were selected based on features such as 3-4m water column depth, moderate flow of water, proximity to the river bank, distance from the navigation channel and proximity to the stakeholders' residences. Different types of cages were fabricated using various materials such as bamboo, coconut pole[1], Iron and Aluminium rods etc. The main frame of the cages of 5m x 2m x 2 m (Length: Width : Depth) with a volume of $20M^3$ were fabricated with iron rods, coated with antifouling paints to withstand the attack of biofoulers(fig. 2a & 2b). Six airtight plastic barrels (200Lr) were tied to the main cage to float the cage in the water body. The main cage was partitioned into three compartments of 1.5m x 2m x 2 m area (fig. 3-5) The "Microsate" units were anchored in the water body using wire ropes which were tied to fixed coconut poles* in the river bed at both sides of the cage. Each cage compartment was encircled by two net layers - an outer high density polyethylene (HDPE- 20 mm) and an inner nylon press net (12 mm). The nets were tied to the main frame with polyethylene ropes. Sand filled PVC pipes (20mm) of 1.5m x 2m x 2 m dimension were used to keep the nets in position. The top portion of the cage was covered with low cost HDPE nets to protect from predators and poachers. Catwalks on the top portion of the cage were constructed with locally available bamboo and coconut poles for easy handling, monitoring and managing the cages (Fig. 6).

2.3 "Microsate" cage fish culture

Hatchery reared fingerlings (6-8 cm in size, weighing 7-14 gms) of Asian seabass, *Lates calcarifer* were brought from Rajeev Gandhi Center for Aquaculture (RGCA), Myladuthurai, Tamil nadu, India for stocking in the cages. The fingerlings were screened for Viral Nervous Necrosis (VNN) using nested PCR (OIE 2006) as this is the only finfish virus reported from India (Azad *et al.,* 2005). The pearl spot (4 to 6cm) fingerlings were collected from the nearby water bodies using traditional fishing methods and stocked in the cages along with the seabass. The fingerlings were initially fed with pelletized feed (43% protein) of 1.5mm size by hand at 06.00h and 18.00h daily. The fingerlings were later weaned to trash fish feed (100% of body weight initially and 5 - 8% during the last phase of the culture), which mainly included cleaned sardine (after removing the head and gut contents) for improving the economic viability of the culture. Stocking in the rearing cages was done during the month of November at the rate of 130 fingerlings M^{-3} with a biomass of $2kgM^{-3}$. Monthly grading was done to prevent unequal growth and cannibalism among the Asian seabass fingerlings. Representative fish samples were collected fortnightly to ascertain the health status of the fish. The cage nets were cleaned thoroughly once in three days and the inner nylon nets replaced fortnightly by new/cleaned ones. The "Microsate" cages were harvested after the seven month period and were sold in the domestic markets.

[1] *The coconut (Cocos nucifera) is a large palm, growing up to 30 m, tall and hardy and the main trunk is generally used for construction works and Kerala is known as the Land of coconuts*

3 RESULTS

Different types/designs of cages were fabricated and tested using various materials such as bamboo, coconut pole, Iron and Aluminium rods etc. The experimental culture using different designs revealed the suitability of the present "Microsate" design using the durable materials described earlier using iron rods, airtight plastic barrels, HDPE and Nylon nets. The present design appeared to be superior to others in have the following advantages- a) to resist heavy water currents during monsoon and tidal fluctuations, b) to hold the heavy biomass towards the end of the culture, c) to hold human weight since cage culture requires continuous monitoring and grading.

3.1 Production potential of the "Microsate"

After seven months of "Microsate" cage culture, the Asian Seabass and Pearl spot reached an average size of 675 ± 75 gm and 250 ± 50 gm respectively. The overall survivability of the Asian seabass and Pearl spot after seven months culture period was 85 percent. The successfully completed first term "Microsate" cage culture harvest festival was inaugurated by Mr. S Sharma Hon. Minister to Fisheries, Govt. of Kerala (fig.7). A total of 663 Kg of Seabass and 106 Kg of Pearl spot per microsate cage culture unit were harvested and were sold in the domestic market for a good price Rs. 250± 25 Kg-1 ($ 6-7) as per the average weight (fig.8-9). A detailed cost benefit analysis of the "Microsate" cage fish culture has analyzed and furnished bellow in detail (Table1).

3.3 Major problems encountered

One of the major problems encountered during the culture was the menace due to biofoulers which included edible oyster, green mussel, bivalves, sea grass etc. The biofoulers clog the net, reduce the flow of water and provide an attachment substratum for other organisms. Periodical cleaning of the nets and frames were found to be best method to get rid of the biofoulers from the cage nets. Mortalities were observed initially in the fingerlings of *L. calacrifer* stocked in the cages. Investigations revealed that the recurring mortalities in the cages were due to the attack of *Cirolana fluviatilis*, an isopod pest. Though *C. fluviatilis* has been reported earlier from many water bodies in Southern India (Cherian 1977, Mathew et al., 1994), this was the first report of a mass mortality caused by *C. fluviatilis* from tropical cage culture systems in the Southwest coast of India (Sanil *et al* 2009).

3.4 Management strategies developed to get rid of biofoulers and parasites

- Routine monitoring and maintenance of outer and inner nets turned out to be the best practice to reduce biofouling. This enhanced the water flow through the nets and will deprive the chance to of isopods/parasites to attach and flourish in the cages.
- Biological control of biofoulers and predatory parasites can be attained by stocking grazing / omnivorous fish species, which can actively clean the periphyton and small

attaching organisms from the nets, which in turn reduce the sea grass growth in the cage netting and also reduce the parasitic organisms attached to the cage nets.

- Use of antifouling nets/agents can be attempted as a control measure against biofoulers.

3.5 Scaling up the interventions

Based on the highly encouraging results of this venture, efforts are being made to popularize the "Microsate" cage farming in the coastal areas by the Government of Kerala and other entrepreneurship development agencies. Presently, for scaling up the "Microsate" cage culture activities among the Tsunami affected coastal fisherfolks of Kerala, Japanese Fund for Poverty Reduction (JFPR) has taken the initiative and is giving financial aid to the fisher folks of Kerala to start the "Microsate" cage as an alternative income generating programme. "Microsate" cage culture was implemented through different Non Governmental agencies and Kottappuram Integrated Development Society (KIDS), an NGO operating in the area was selected as a nodal agency for giving the technical and scientific support to the fishers. Presently, as a part of expanding the culture activities, 25 "Microsate" units were implemented in the Vembanad Lake close to Azhikode bar mouth in the Periyar River.

4 DISCUSSION

4.1 Development of innovative 'Microsate' floating cages

Lack of suitable food production systems is one of the key obstacles in addressing the food insecurity of the world population. At present, all the food producing sectors are facing problems associated with environmental degradation and increasing land and water scarcity (FAO, 1999). The "Microsate" concept is an ideal alternative to these challenges as well as helps to protect the biodiversity through an ecofriendly approach. Some of the salient features of the "Microsate" cage culture programme are as follows:

- Ecofriendly and low volume, high density food production system ideal for small scale farmers
- Low capital input and minimal operational cost which ultimately leads to sustainable fish production
- Locally available low value trash fish can be used as feed which in turn reduces the operational costs
- High survival rate, control in feeding and easiness in monitoring and management
- Relocation of "Microsate" is possible at time of emergency with minimum effort.
- Harvest can be done at minimum time as per the requirement of the consumers and can thus fetch premium price.
- Most advisable fish culture model to address the nutritional and livelihood insecurity of poor inland fishers

4.2 Indirect benefits of "Microsate" culture ventures

- Better management and utilization of inland water bodies for high rate of fish production
- High fish production will reduce fishing pressure on wild fish groups and can promote the indigenous fish species culture
- Potential to develop live fish marketing centres
- "Microsate" cages can be used as sport fish centres for tourists, which can bring in additional income to the farmers.
- Most environmentally advisable culture practice for the sensitive backwater systems of Kerala.
- An ideal fish culture technology which can be implemented even by the landless fisherfolk.
- A sustainable and new fish farming technology which can be easily disseminated all over the country among the fisher folk.

4.3 Technical feasibility of "Microsate" cage culture in Kerala situation

Kerala state with its 590 km coastal belt, exclusive economic zone of 36,000 sq. km, fresh water area of 158358 ha and brackish water resource of 65213 ha has all the requisite natural endowments for building a strong fisheries economy (www.india.gov.in). Marine fisherman population in Kerala covers about 846088 persons, which includes men (331435), female (296912) and children (217740) (www.fisheries.kerala.gov.in). The newly developed "Microsate" cage can be used as a successful fish production system using the abandoned water bodies and unutilized manpower existing in the country. The raw materials used for the construction of the "Microsate" cages are long lasting and durable and hence the same cage can be used for a minimum of five consecutive culture ventures. The size of the "Microsate" unit was suitable for small scale culture and can also be moved/shifted when needed with minimum manpower and this could be an added advantage for the small groups having less members.

4.4 Sustainability of "Microsate" in fisherfolk hands

Sustainable fish culture methods with the active participation of fisher's community are very less. Many of the livelihood programmes implemented through the community appeared to fail repeatedly due to many reasons. Ownership issues, material maintenance and participation were the some of the main issues concerned with the sustainability of livelihood programmes. The present "Microsate" cage experiment have developed new management strategies to address the above issues by developing work groups and work turn. Fish seed (youngones) and feed are the major inputs in "Microsate" programme which directly determine the sustainability of the programme. The fingerlings requirement for the "Microsate" culture can be obtain from the local hatcheries in the various parts of the country. The stakeholders are equipped with the techniques in cage fabrication, transportation, acclimatization, stocking, feeding, grading and harvesting of the cage cultured fishes. The revenue generated from the culture was equally divided and distributed to the members keeping the operational cost required for the next year's culture. The participation of the stakeholders was throughout the seven months of culture process.

One of the major problems encountered in commencing the cage fish culture in India is the non availability of a quality formulated feed. A low cost formulated slow sinking feed developed for Asian Seabass feed from Central Marine research Institute (CMFRI) was successfully tested in the cages and the growth rate and FCR was found to be high (Unpublished data). The development of an optimum feed for Asian seabass was a major breakthrough in "Microsate" cage venture as this would help the fish farmers to achieve good survivability and production and also to reduce the pressure on trash fish, which in turn will reduce the cost of production in future. This "Microsate" model can also be used to culture the fish species that are listed under 'over exploited' category. Most importantly, it acts as a means to propagate the locally preferred fish species which are presently overexploited. This type of food production systems can decrease the fishing pressure on indigenous fish species and can also generate alternative income for the inland rural fishers.

4.5 Tribute of "Microsate" initiatives to Social Development and Gender balance in cage culture activities

The innovative, sustainable, small scale "Microsate" cage culture initiatives could address the livelihood and nutritional insecurity of the rural fisherfolks. Group level meetings and activities conducted periodically improved the technical and coordination skills of the members. Stakeholders were actively involved and contributed their experience and indigenous knowledge in the "Microsate" culture activities especially in selecting the sites for culture. Trainings conducted for the stakeholders improved their skills in fabrication of the cages, monitoring, rearing, feeding and grading of the fish. The stakeholders took initiatives for collecting the indigenously available pearl spot (*Etroplus suratensis*) young ones using the traditional fishing methods. Women stakeholders were actively involved in the cage culture activities especially in the collection of raw materials for fabricating the cage, collection and preparation of trash fish, cleaning and monitoring of the cages and harvesting and marketing. The stakeholder groups were mobilized for the smooth implementation of the processes by conducting meetings and trainings at regular intervals. Women play a critical role both in the domestic and economic spheres in rural communities. But majority of the female members in the inland fisher community earlier remained unemployed or severely underemployed. Their immediate neighbourhood offers very few opportunities for gainful employment and their social background also deterred them from entering the complicated and highly competitive urban employment markets. "Microsate" cage fish culture initiatives have immensely contributed to strengthen women's empowerment. Mainly, this intervention has increased the self confidence and strengthened the role of women in the decision making processes. For the successful implementation of any development / poverty alleviation programmes, women should be actively involved and the social impact made by the "Microsate" cage culture experiment in the community has proved this.

5. CONCLUSIONS

The pioneer venture on "Microsate" cage farming of Asian Seabass and Pearl spot in the south west coast of India turned out as a great success and fulfilled all the major objectives. This endeavour for livelihood and nutritional security of the rural fisherfolks has become a promising intervention in India and this have the potential to scale up globally to increase the employment opportunities, social status of the fisherfolks and aquaculture production. Fisher folks 'Own Fish Farm' dream can be fulfilled through the presently developed innovative "Microsate" concept.

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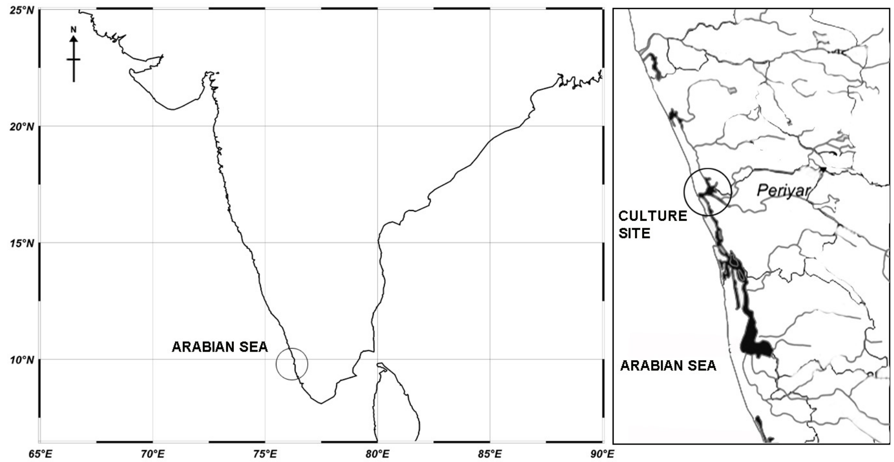

Fig 1: Map of the Southwest coast of India showing the culture site.

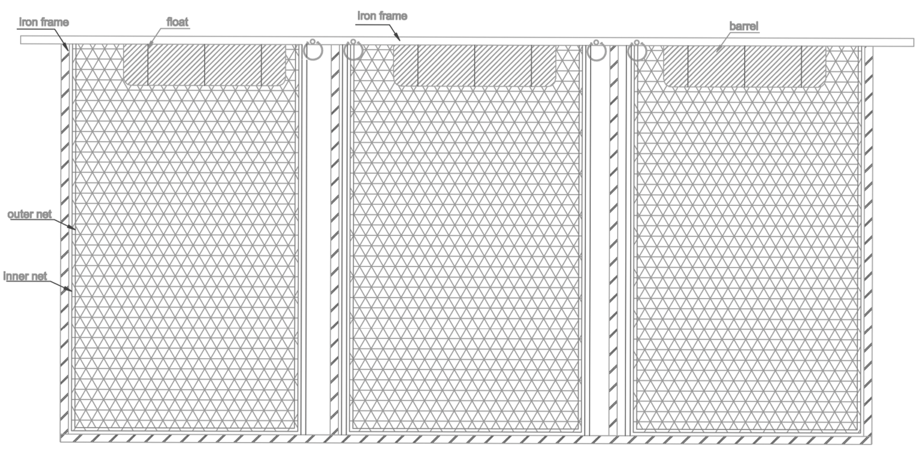

Fig. 2a

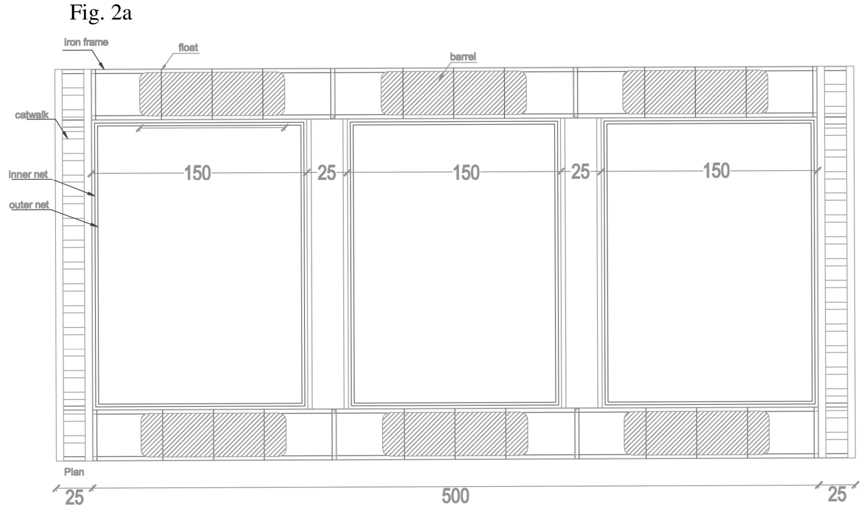

Fig. 2b

Fig 2a: Schematic representation of "Microsate" floating cage unit- Cross section.
Fig 2b: Schematic representation of "Microsate" floating cage unit- Top view

Fig 3-5: Fabrication of the "Microsate" cage by the fisherfolks
Fig 6: "Microsate" cage floating in the water body

Fig 7: Inauguration of first harvest festival of the "Microsate" by the Mr. S Sharma Hon. Minister to Fisheries, Govt. of Kerala.
Fig 8-9: "Microsate" cage harvested fishes

Table. 1 COST-BENEFIT ANALYSIS –"MICROSATE" CAGE CULTURE PROGRAMME

Total area (m^3)	*20*
Cost for single "Microsate" Unit	*58,000*[2]
Yield of Asian seabass harvest (Kg)	*663*
Yield of Pearl spot (Kg)	*106*
Length of cycle (months)	*7*
Price of fish (Rs/.)	*265*

Operational cost for first term "Microsate" culture

Asian Seabass Fingerlings (Rs. 10/- X)	*11,000*
Feed (Trash fish & Pellet feed)	*60,000*
Other Expenses	*10,000*
Total	***81,000***
Income	
Asian seabass (Plate size 663 Kg X Rs. 265/-)	*175695*
Perl spot (106 Kg X Rs.250/-)	*26500*
Total	***202195***
Gross profit after one time "Microsate" culture	*121195*
Net profit in the first year culture	***62695***

Operational cost for second term "Microsate" culture

Maintenance cost in second term culture	*10,000*
Operational cost in second term	*90,000*
Total	***100000***
Income	
Total Income in the second term culture	*202000*
Gross Profit in the second term "Microsate" culture	*102,000*
Net Profit in the second term "Microsate" culture	***102,000***

[2] *In Indian rupees, 45 INR~ 1US $*